Predicting Zoonotic Hemorrhagic Fever Events in Sub-Saharan Africa using NASA Earth Science Data for DoD - Global Emerging Infections Surveillance and Response System

Jorge E. Pinzon, SSAI at NASA/GSFC

Public Health Program Review
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Newport, RI

Contributors

Remote Sensing Data

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Field Surveillance & Data Support

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Armed Forces Health Surveillance Center

• Kevin Russell, Clair Witt: Div GEIS Operations, Silver Spring, MD

World Health Organization

• Pierre Formenty

Overall Goal: strengthen DoD-GEIS efforts to build a sustainable global capacity for predictive surveillance to promote preparedness in US Forces, the Military Health System and the Global Public Health community.

Specific aims:

- Get a better understanding of eco-climatic/disease linkages and their critical pathways to support surveillance and control activities.
- Refine the early warning models for Rift Valley Fever (RVF), and Marburg/ Ebola Hemorrhagic Fever (MHF/EHF) filoviruses in Sub-Saharan Africa with multi-level monthly risk maps.
- Study potential **extension** of models to other regions and diseases.
- Prototype the development and production of an environmental quality data record (NDVI-rainfall-temperature) that ensures **consistency** and **continuity** of data ingest to early warning models and **transferability.**
- Analysis, predictions and models that provide timely and coherent SYNTHESIS of otherwise disparate information

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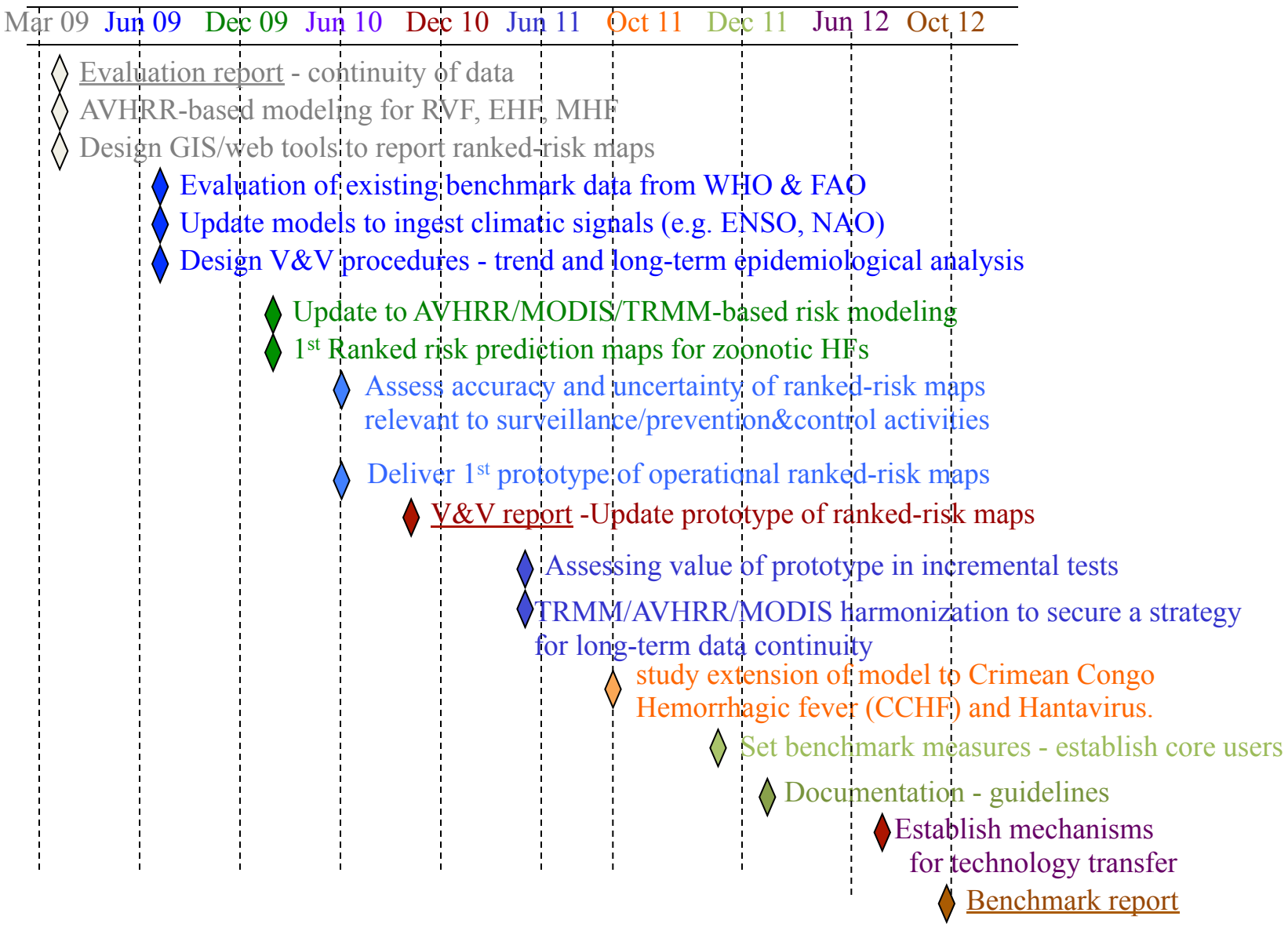
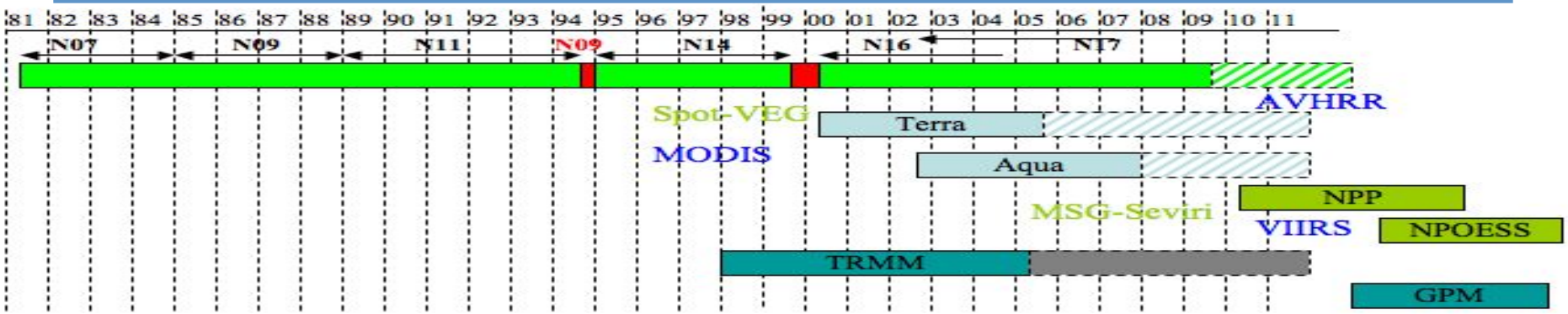
Project milestones



Data harmonization

Securing long-term data continuity



Inputs	Current Sensor/Data	Integrating Intermediate data	Extended long-term monitoring
Global Climate indicators Multivariate ENSO Index NAO, PDO **Disease, Vector & Animal Data** Imagery time series Precipitation (PPTN) Normalized Difference Vegetation Index (NDVI) NDVI / Temperature	Sea Surface Temperature (SST) Outgoing Longwave Radiation (OLR) From NOAA(monthly updates) Latitude&Longitude&Date TRMM - monthly update AVHRR - biweekly or as needed MODIS - monthly	SeaWIFS MODIS Hyperion data	GPM / 2013 NPP-VIIRS 2011

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NASA/GIMMS Production System
Extending model

AVHRR
1981 - present

-Geolocation
-Calibration
-Cloud/Shadow Screening
-Atmospheric Correction

Land products

Gridding

AVHRR products

Other Risk Indicators

-Animal surveillance
-Vector habitats
-Human cases

MODIS
2001 - present

-Geolocation
-Calibration
-Cloud/Shadow Screening
-Atmospheric Correction

Land products

Gridding

MODIS products

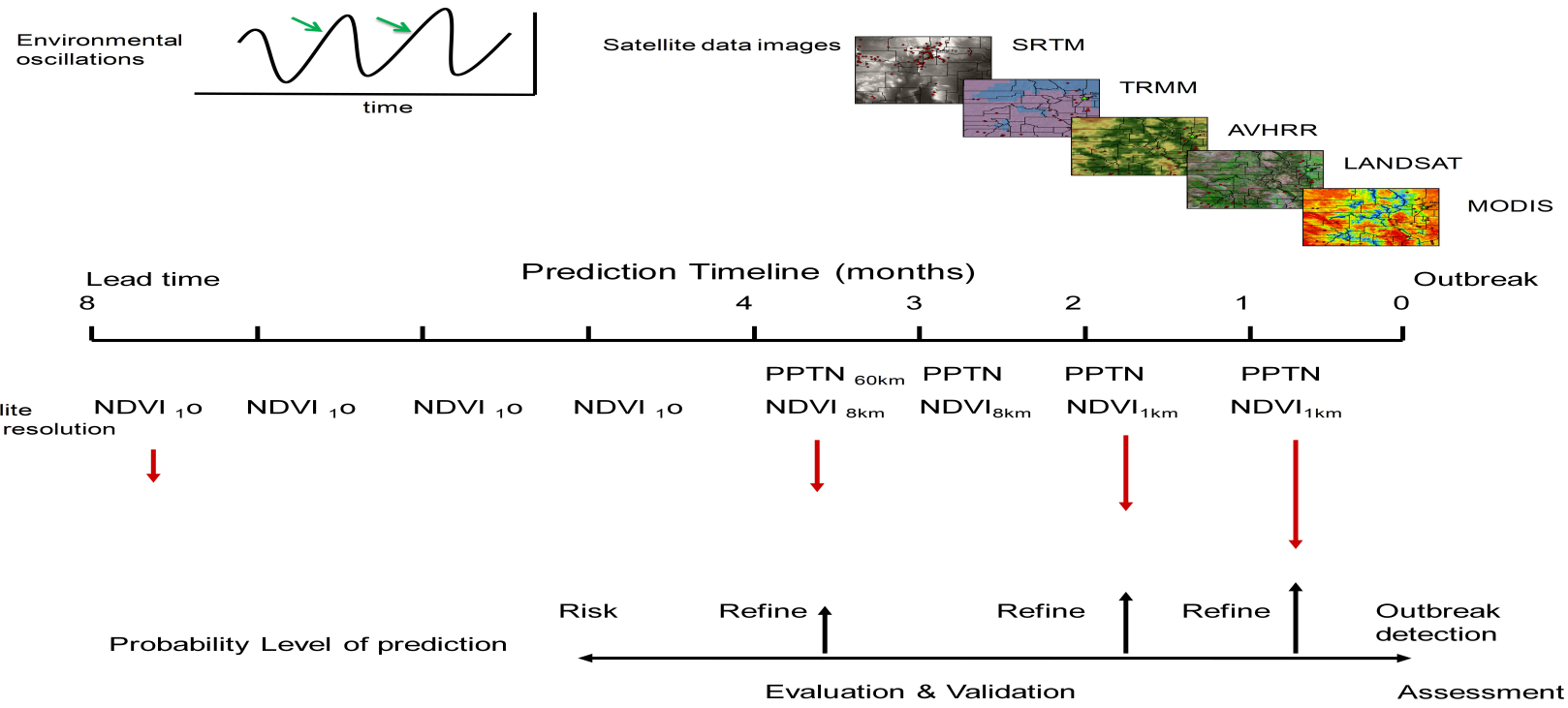
ENSO + DEM + LandCover
Precipitation:TRMM

List of potential products:
Surface Reflectance, VI,
Normalized Anomalies,
Spatial&Temporal Ranking
of Risk

Web-based Integration:
Daily, multi-day, monthly
Analysis and dissemination
Benchmark measures
Transfer technology

Spatio-temporal modeling: framework prediction
Accuracy, continuity, expansion and transferability

Model Prediction Framework



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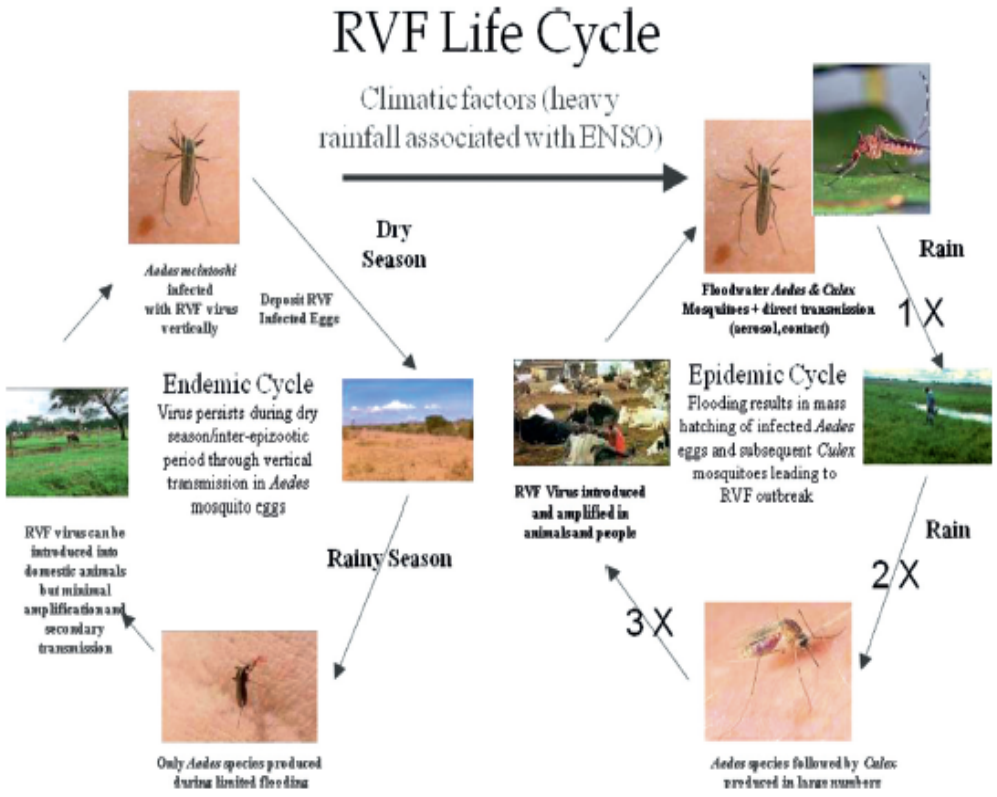
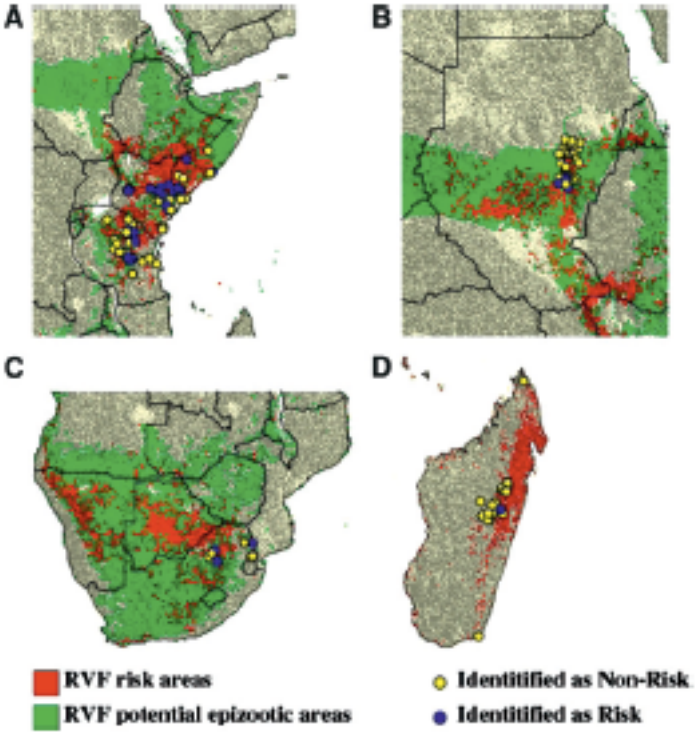
RVF in other regions





Am. J. Trop. Med. Hyg., 83(Suppl 2), 2010, pp. 43–51

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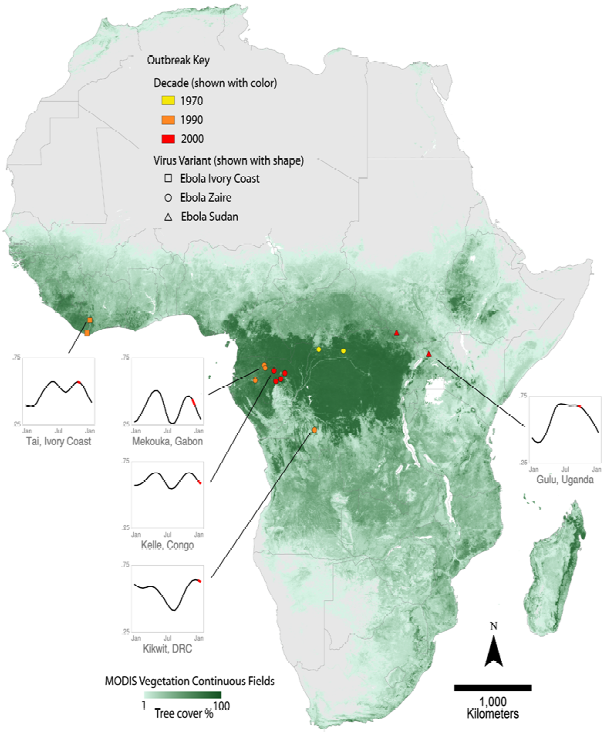
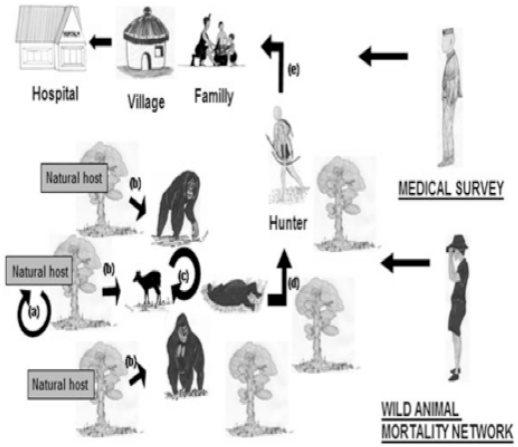
EHF - Modeling

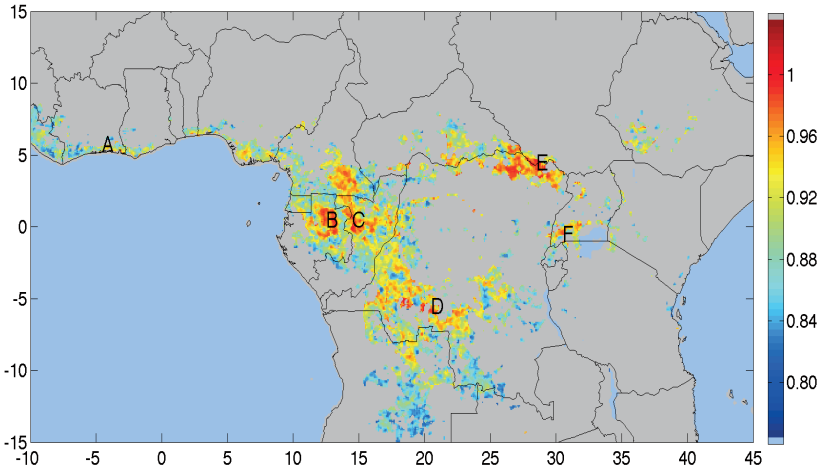


Pinzon et al. ajtmh 2004



Ebola Cycle:

Rouquet et al. EID 2005



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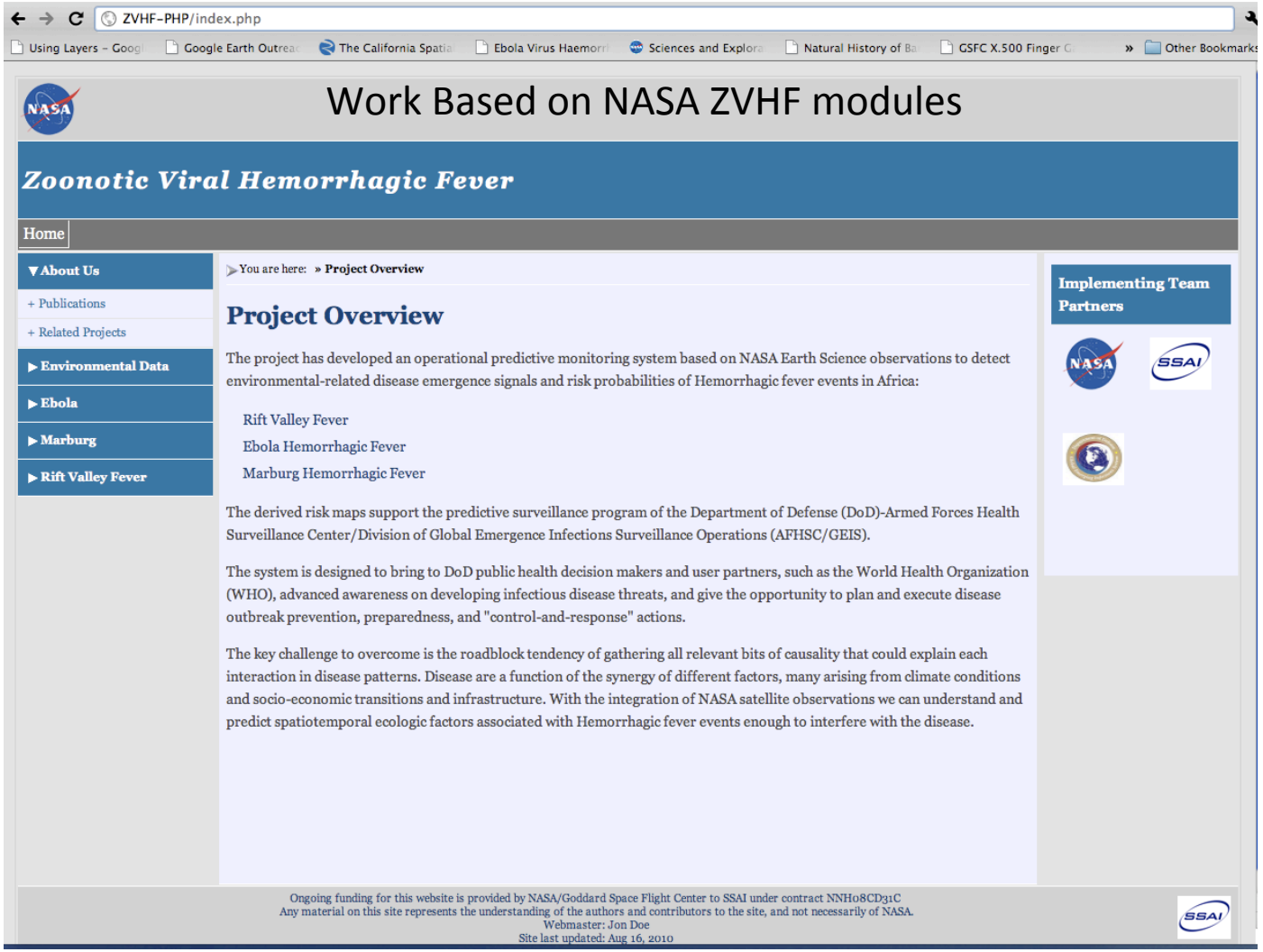
Technology transfer



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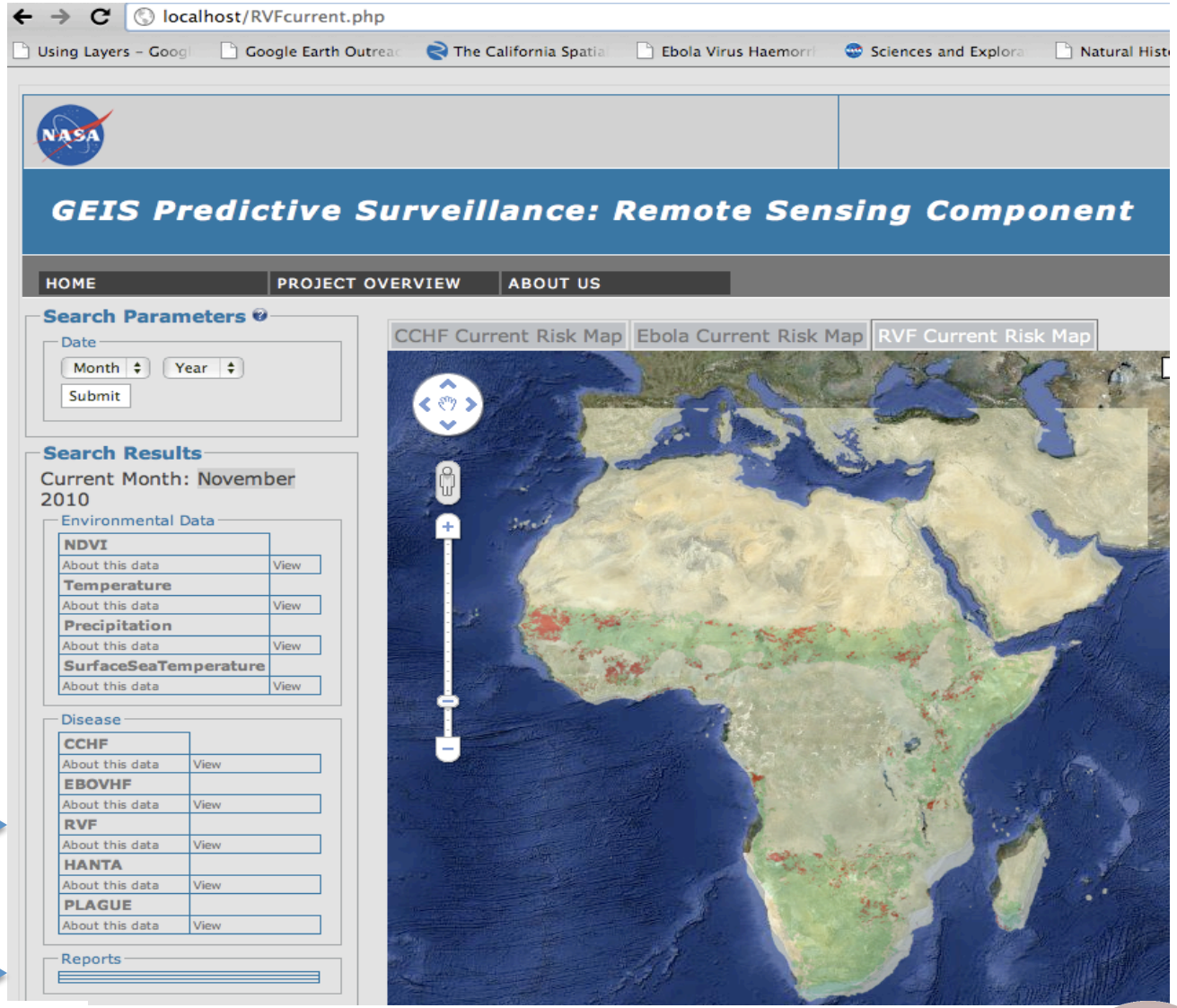
Communication and transfer of data

RVF Previous Reports

- RVF0907.pdf 11-Dec-2009 18:21 2.4M
- RVF0910.pdf 11-Dec-2009 19:58 2.4M
- RVF0911.pdf 11-Dec-2009 20:06 2.5M
- RVF0912.pdf 17-Mar-2010 15:07 2.4M
- RVF1001.pdf 17-Feb-2010 20:02 2.3M
- RVF1002.pdf 18-Mar-2010 18:25 2.3M
- RVF1003.pdf 15-Apr-2010 11:03 2.6M
- RVF1004.pdf 18-May-2010 15:56 2.7M
- RVF1005.pdf 15-Jun-2010 19:36 2.7M
- RVF1006.pdf 19-Jul-2010 21:21 2.5M
- RVF1007.pdf 13-Aug-2010 07:25 2.4M
- RVF1008.pdf 21-Sep-2010 10:48 2.4M
- RVF1009.pdf 18-Oct-2010 10:46 2.5M
- RVF1010.pdf 12-Nov-2010 13:03 2.7M

RVF

current risk map



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Responding to expansion of AFHSC-GEIS predictive surveillance program

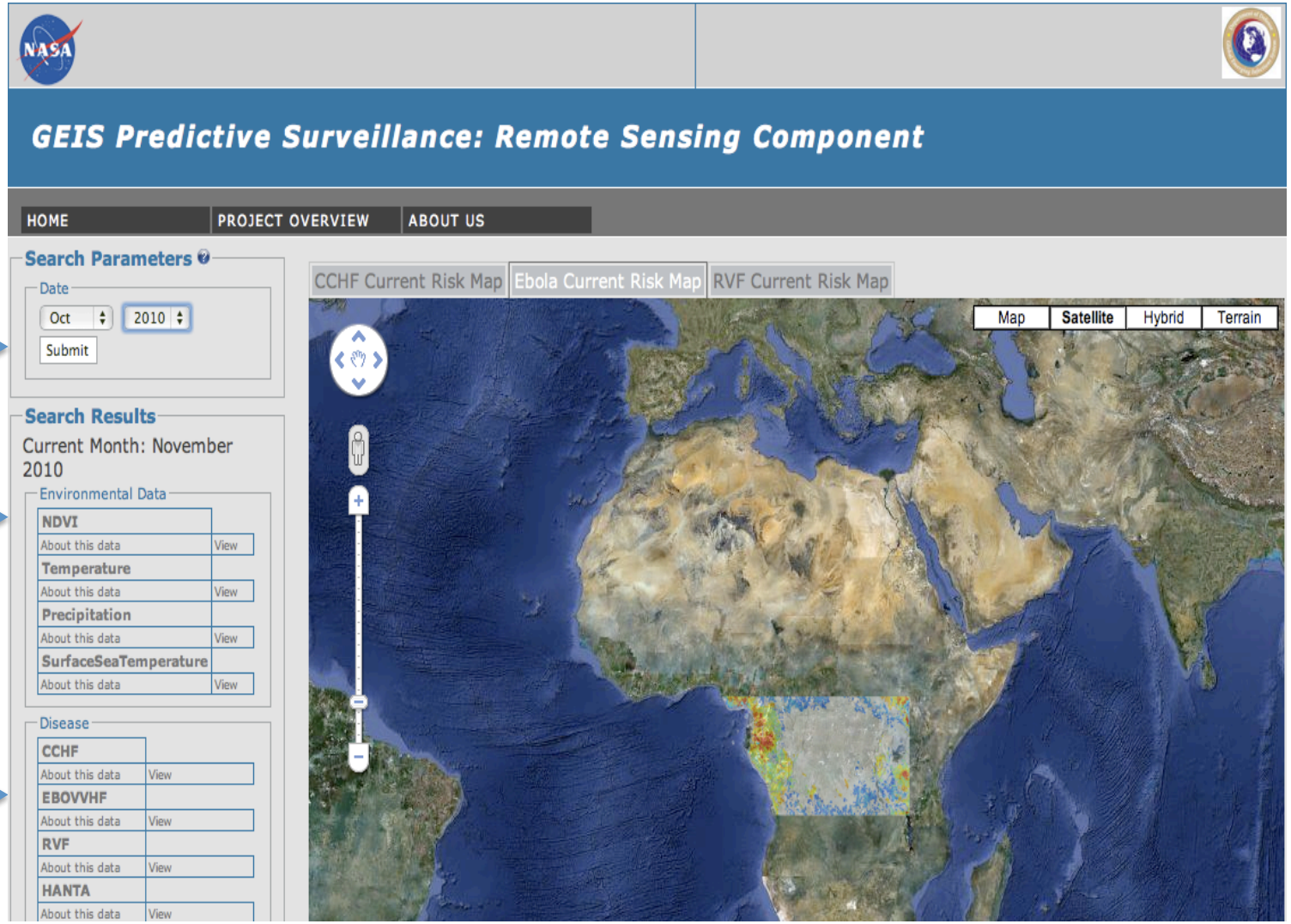
Search

Environment

Embedded in Google maps

Other Diseases

(Ebola)



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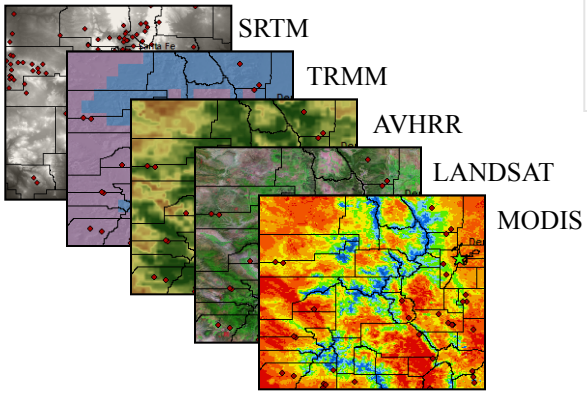
Earth Observations



In situ measurements: vector/animal surveillance & comprehensive list of human cases

INTEGRATED SYSTEM SOLUTION

DATA

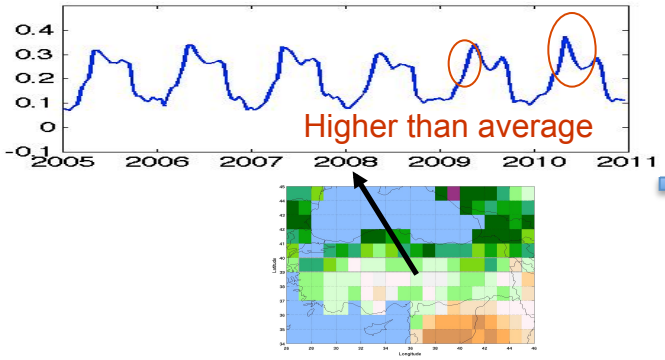
ESD & Models

NASA/GSFC vector-borne eco-climatic modeling

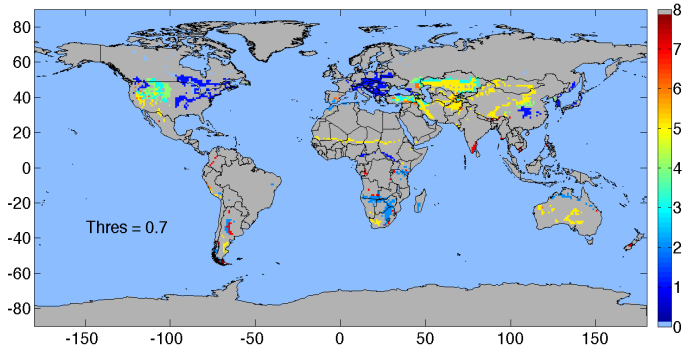
OBSERVATIONS

PREDICTIONS/ FORECASTS

Decision Support Tools

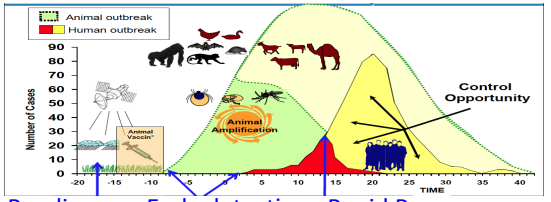


Generalizing



- Temporal/spatial predictive capabilities for monitoring trends in the disease epidemiology/epizootology in a region of interest
- High resolution risk maps for zoonotic surveillance and scientific analysis

- Unique eco-climatic factors or human activities links to increased disease exposure
- Climatic and environmental characterization of risk



Value & Benefits

- Monitoring capabilities for global surveillance and response networking
- Enable timely collections of routine surveillance data
- Enable timely & improved control and prevention efforts
- Better understanding of climate/disease linkage

Improving model – input from partners:
Vector Cycles
dynamics of vector-borne diseases

During an epidemic, the total number of cases at time t+1 due to contacts with cases at time t isestimated as

$C_{t+1} = S_t(1-(1-P)^{Ct})$ Reed-Frost Eq1

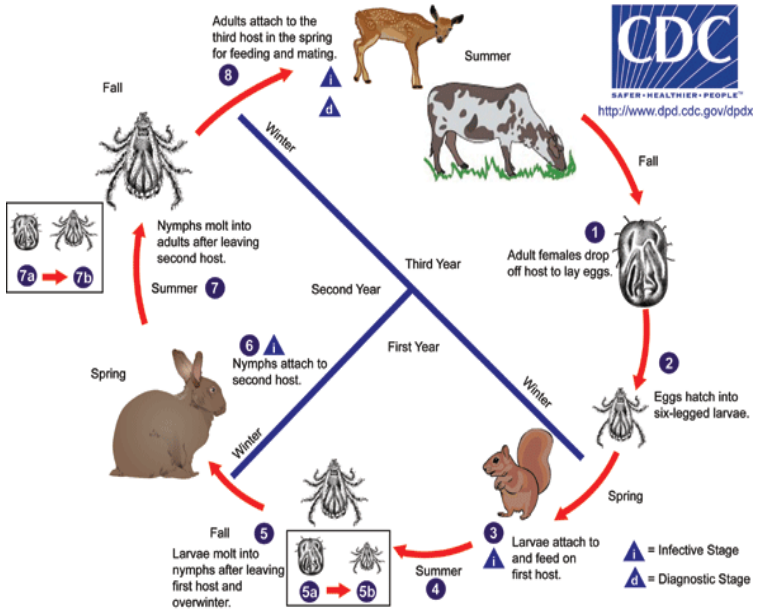
Vectorial capacity (V)

The probability of effective contact is a function of potentially infective bites, P = V/T

$C_{t+1} = S_t(1-(1-V/T)^{Ct})$

$\sim S_t(1-e^{-(V/T)Ct})$ Reed-Frost Eq2

$V = (m \times a^2 \times p^n) / (-\ln(p))m$ MacDonald Eq



Parameters are a function of function of temperature and rain

- 18°C – 30°C: good conditions
- Below 16°C development decreases
- Above 32°C mortality rate is high
- 80mm of rain is suitable

m = [vector density] = function(rain, Ts)

a = [probability of feeding on a hosts in 1 day] = function(G)

p = [probability of living one day] = function(G)

n = [length of EIP in days] = function(rain, Ts, G)

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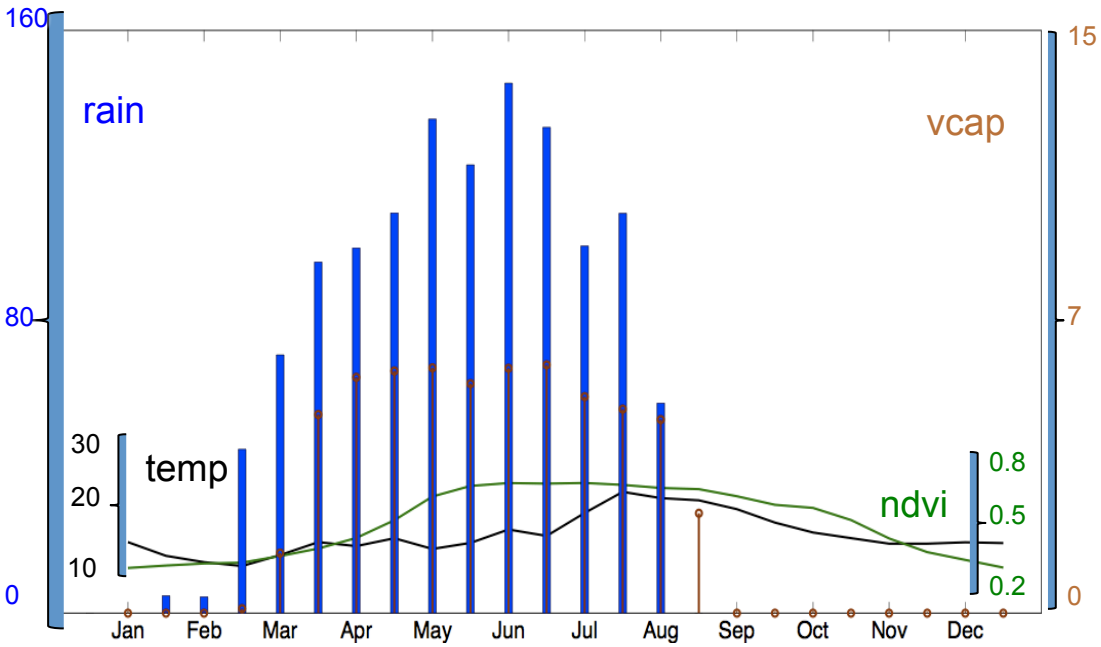
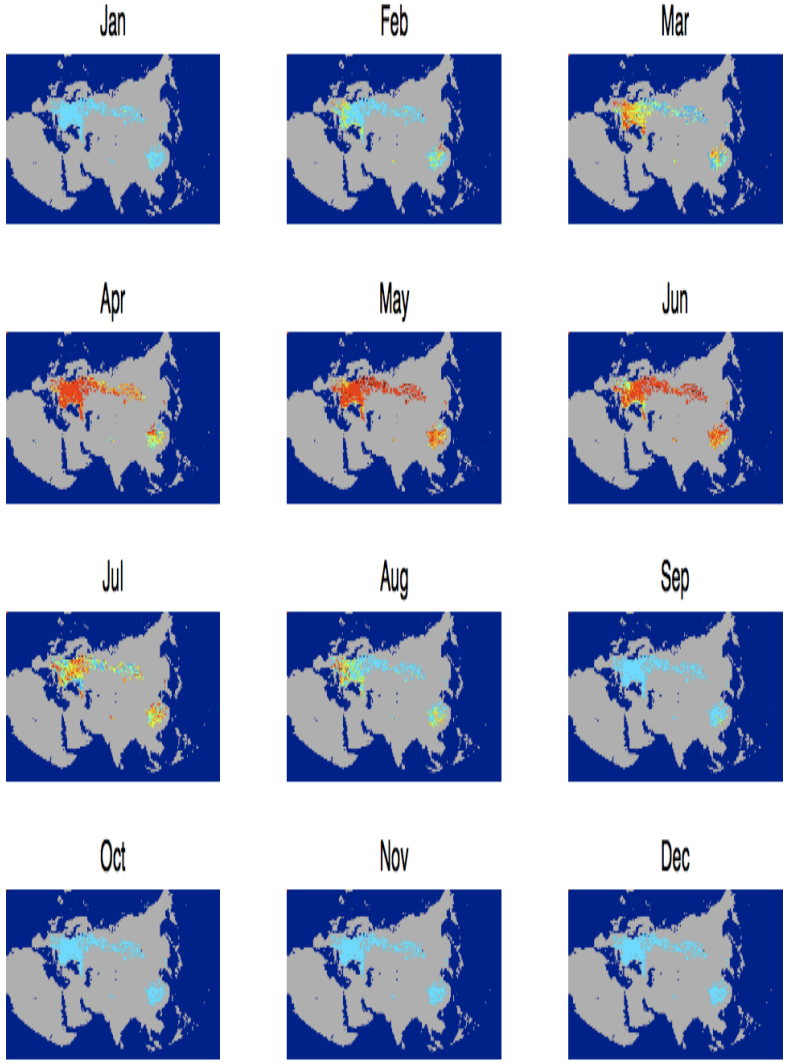
Case study

Hantavirus - vector capacity

Modeling vector capacity dynamics

- Field data from Ukraine
- V as a function of temperature, vegetation index and precipitation



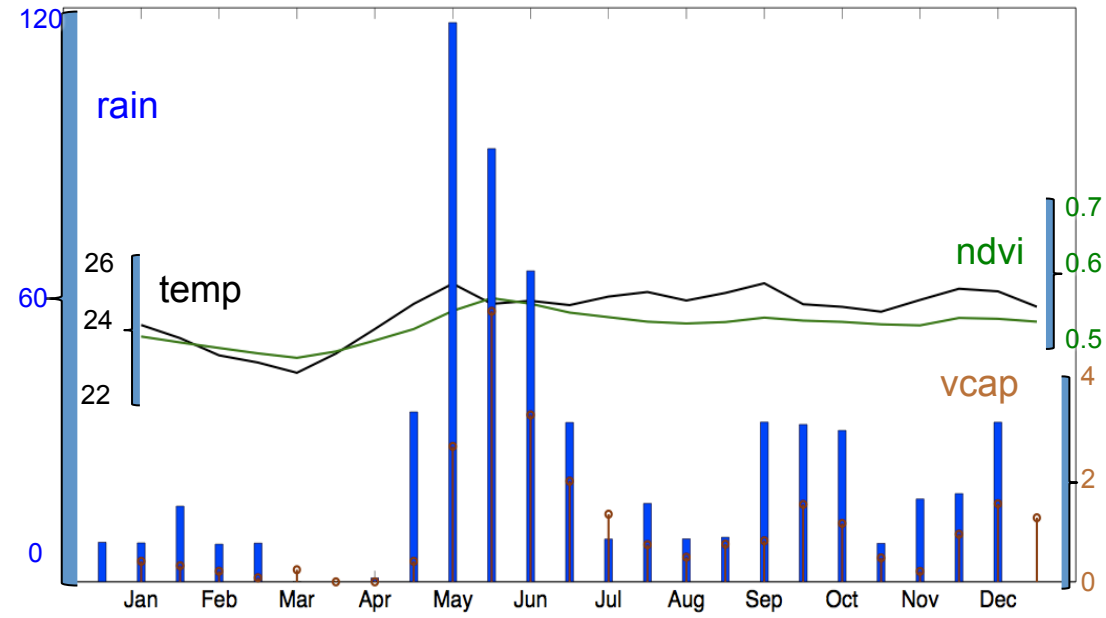


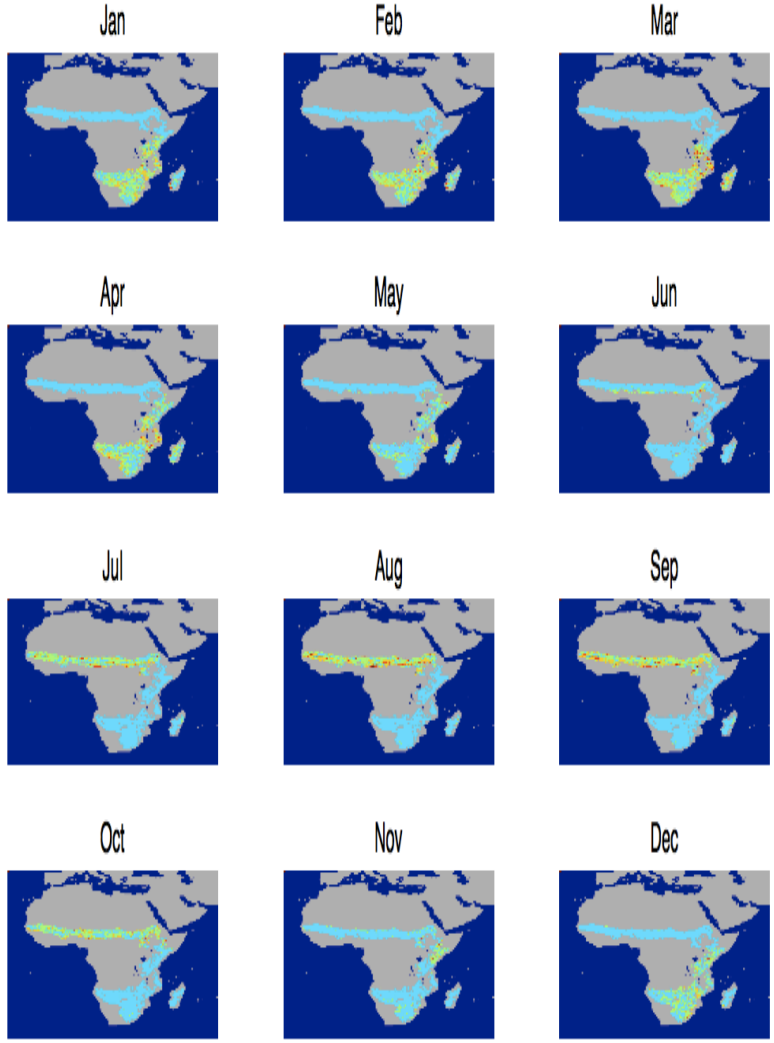
Case study

RVF – vector capacity

Modeling vector capacity dynamics

- Field data from Kenya
- V as a function of precipitation temperature and vegetation index



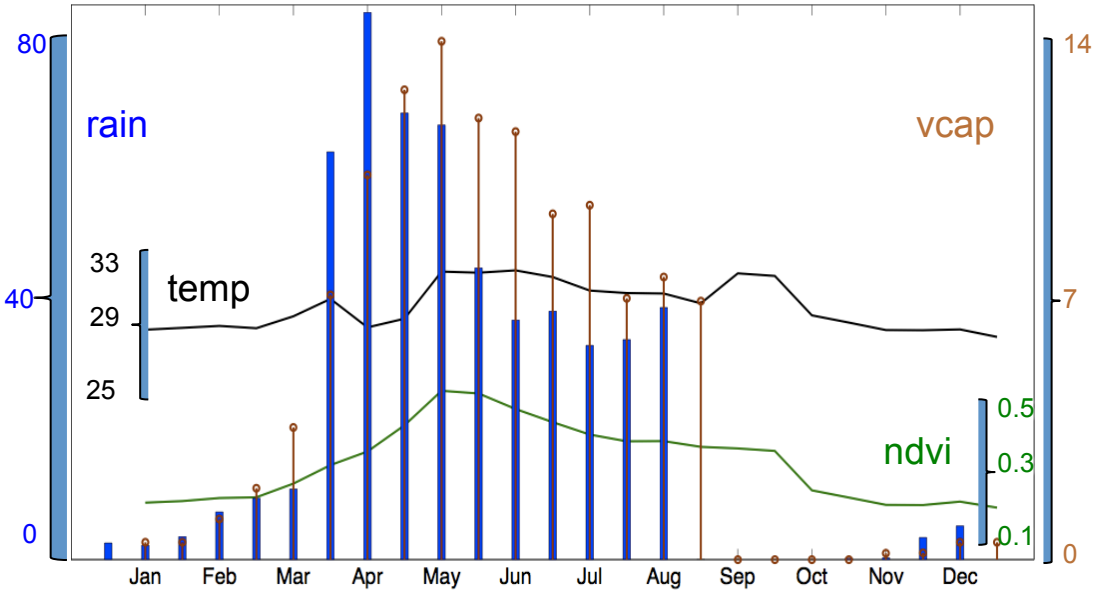


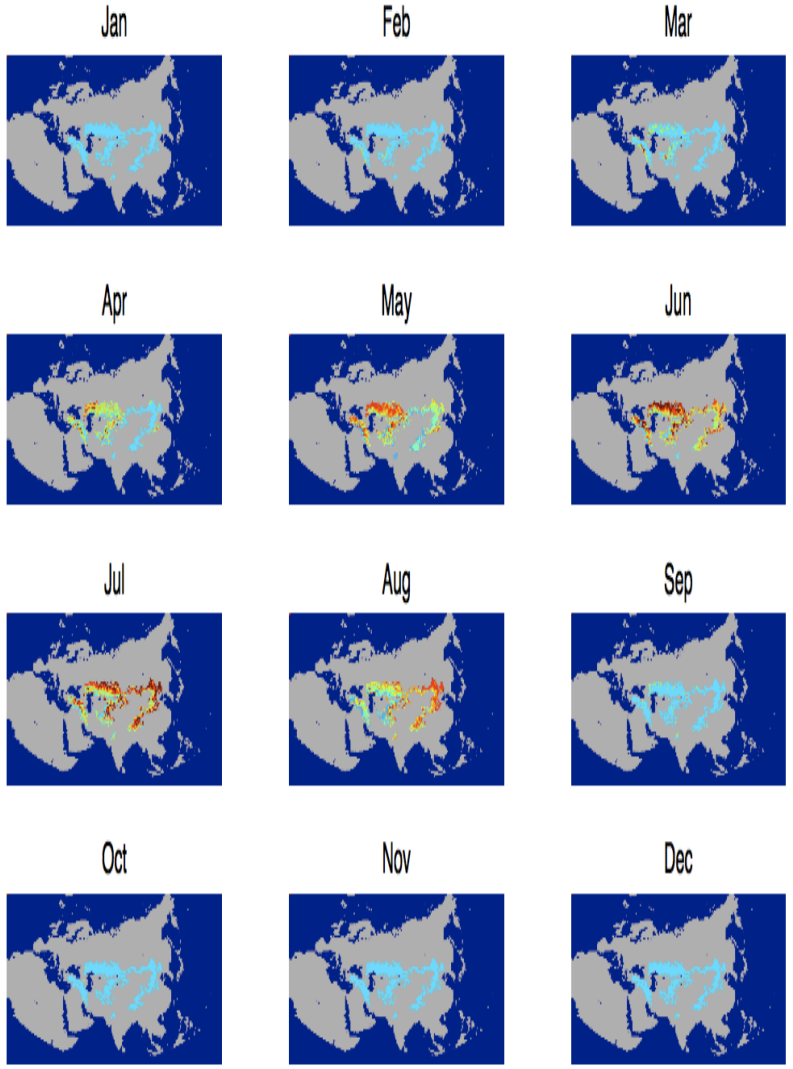
Case study

CCHF - vector capacity

Modeling vector capacity dynamics

- Field data from Turkey
- V as a function of temperature, vegetation index and precipitation



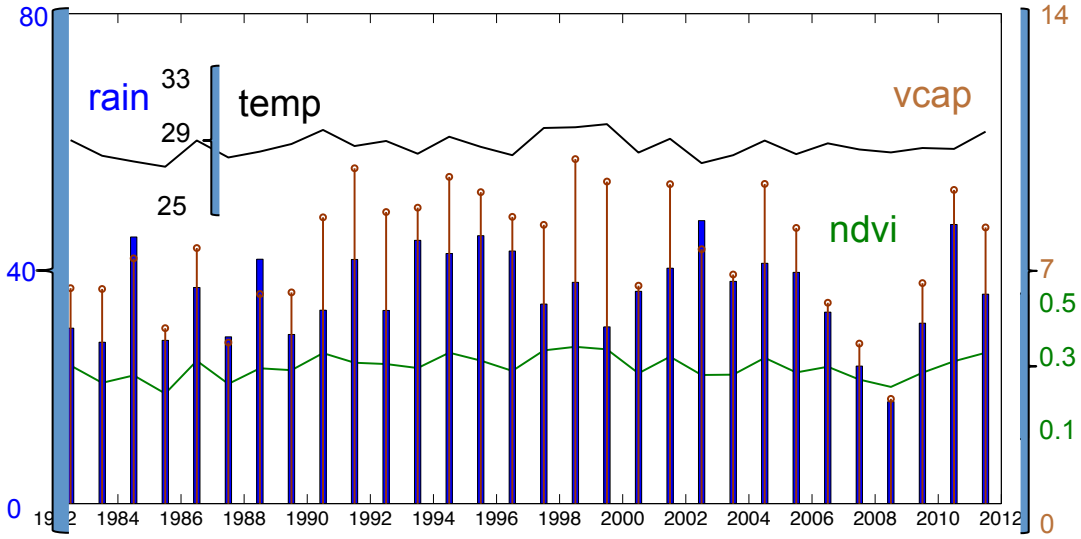


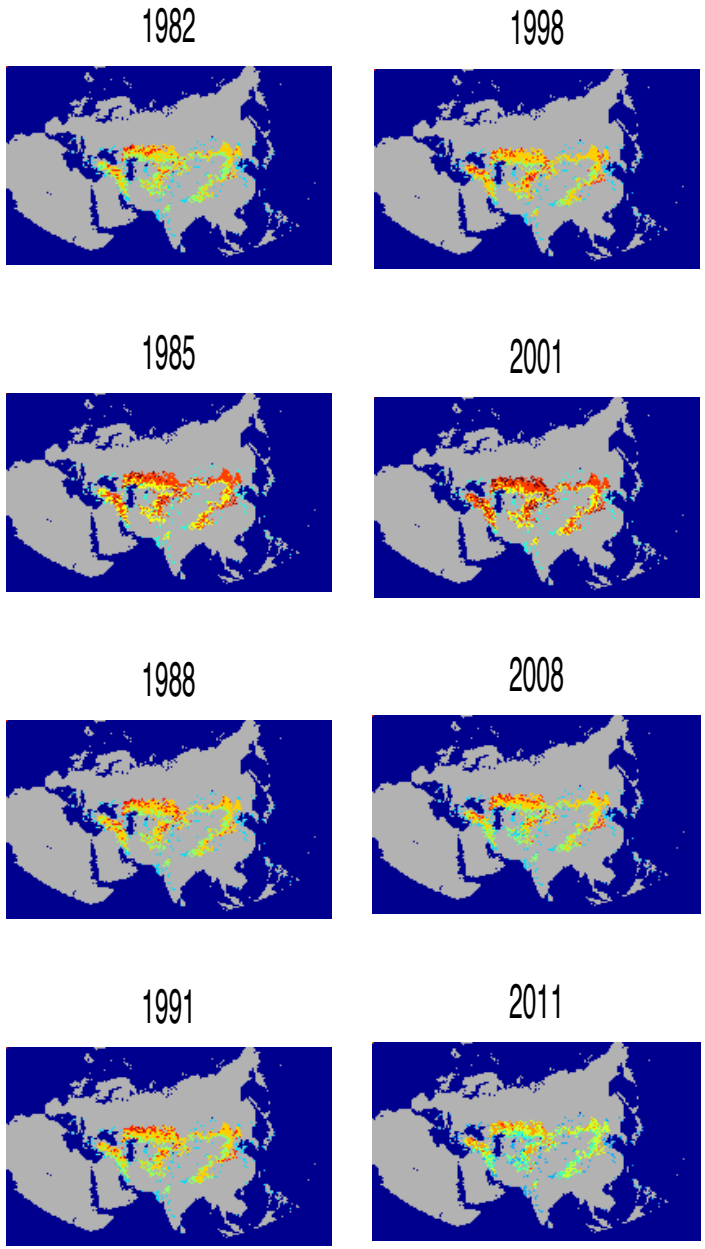
Case study

CCHF - vector capacity
Annual dynamics

Modeling vector capacity dynamics

- Field data from Turkey
- V as a function of temperature, vegetation index and precipitation





Responding to the expansion of AFHSC-GEIS predictive surveillance program

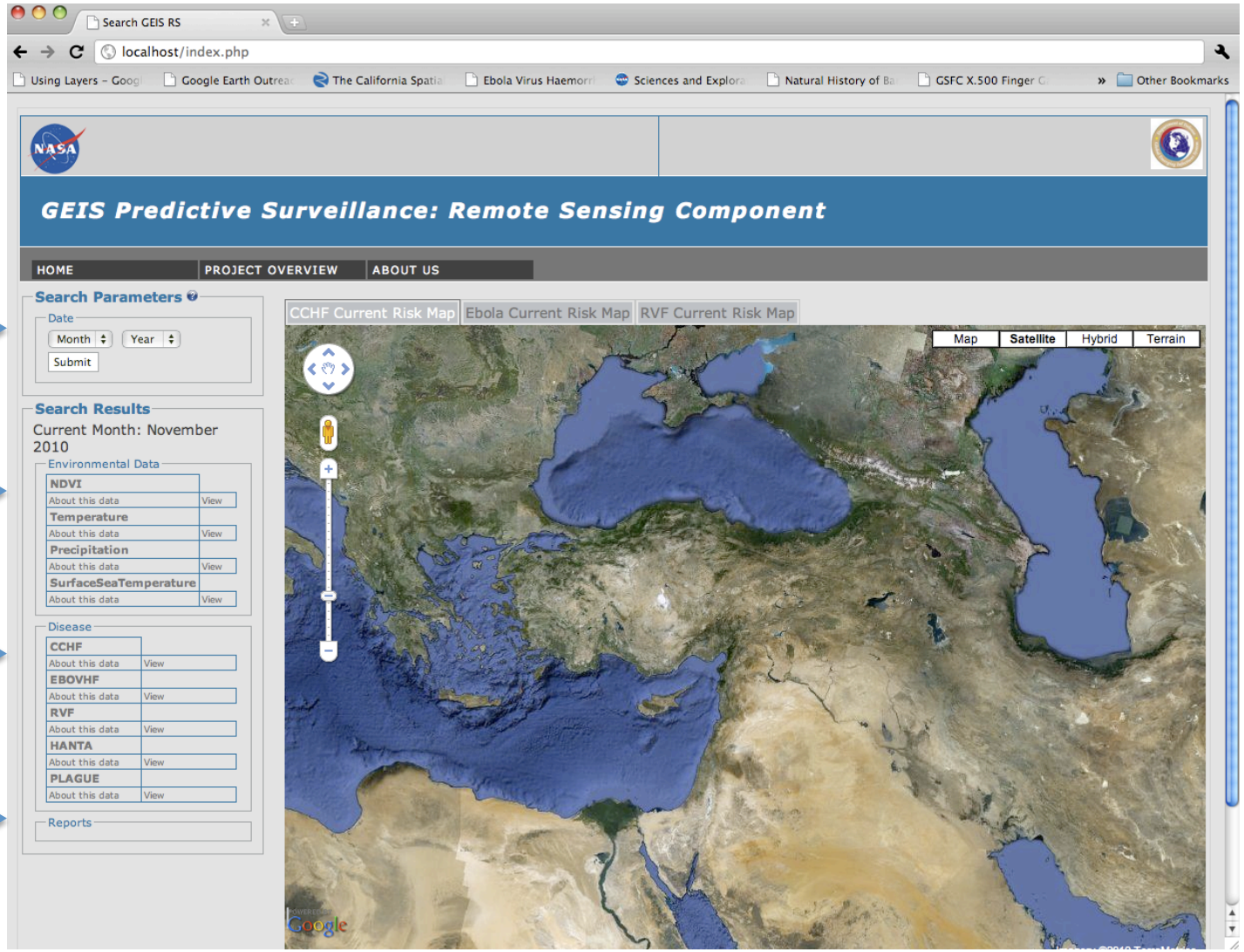
Search

Environment

Embedded in Google maps

Other Diseases *(CCHF)*

Reports



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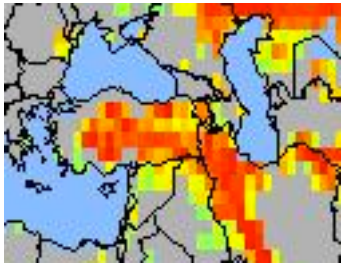
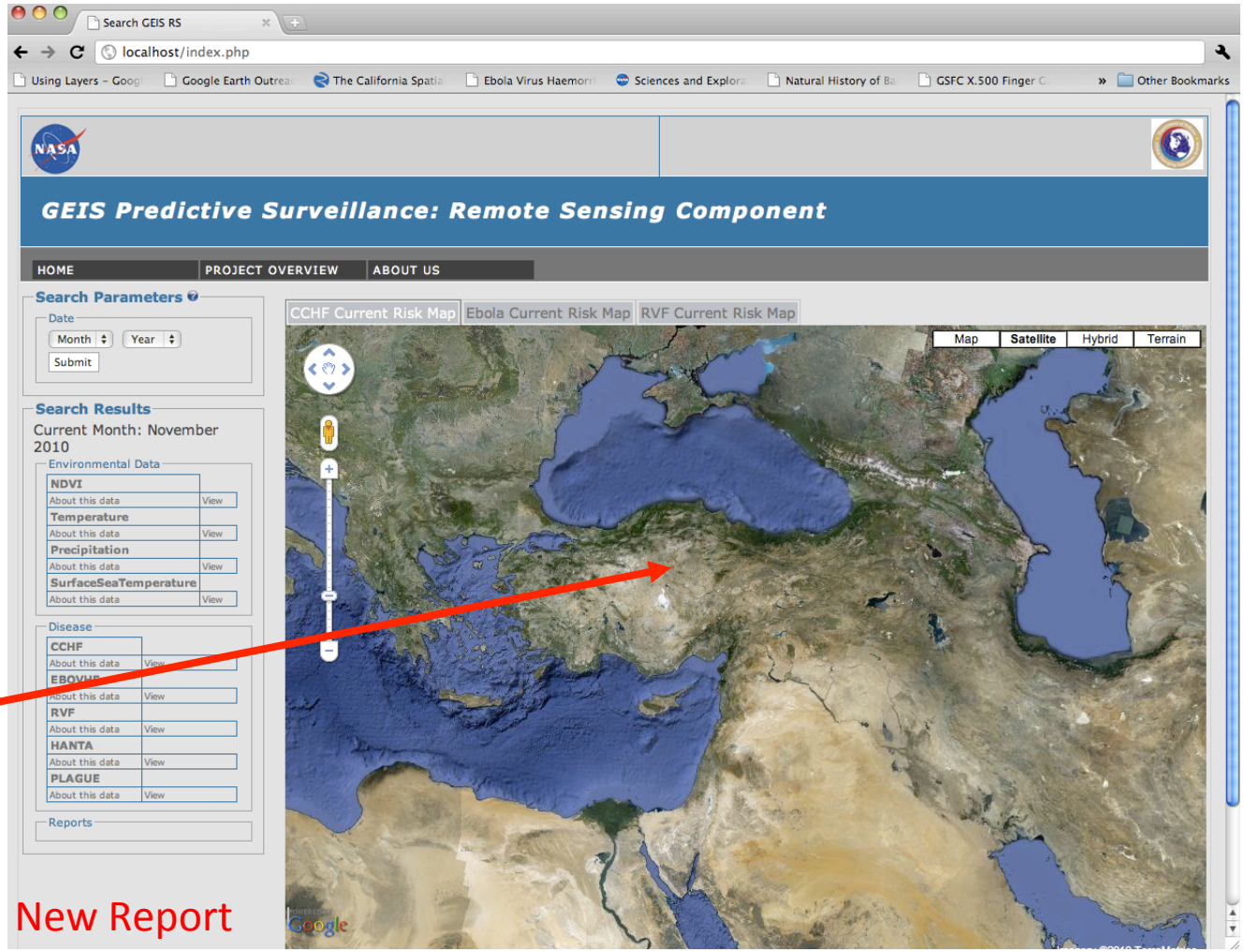
Integrating prediction from data sharing dialog



CCHF Risk



New Report

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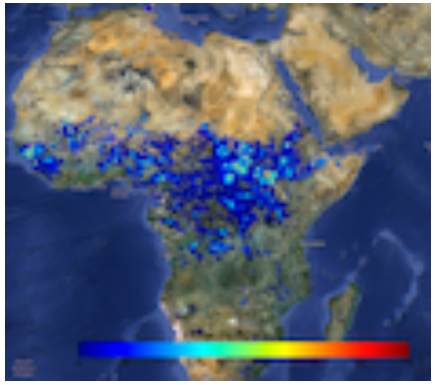
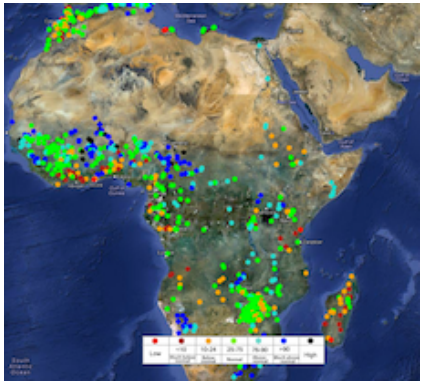
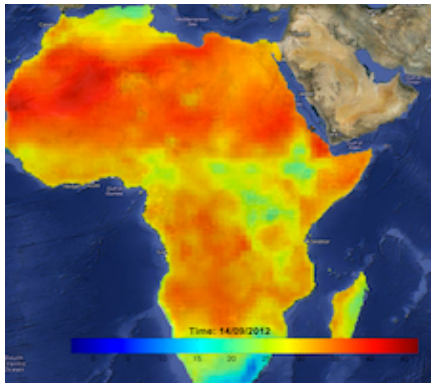
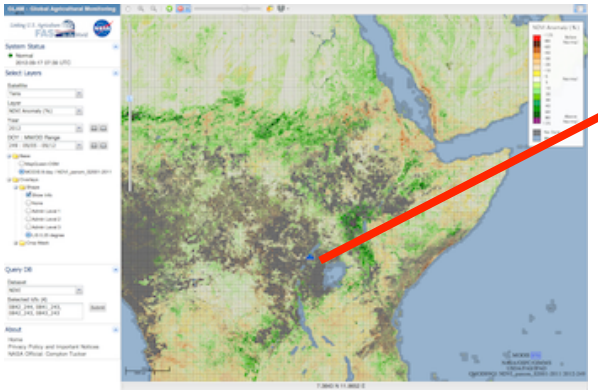
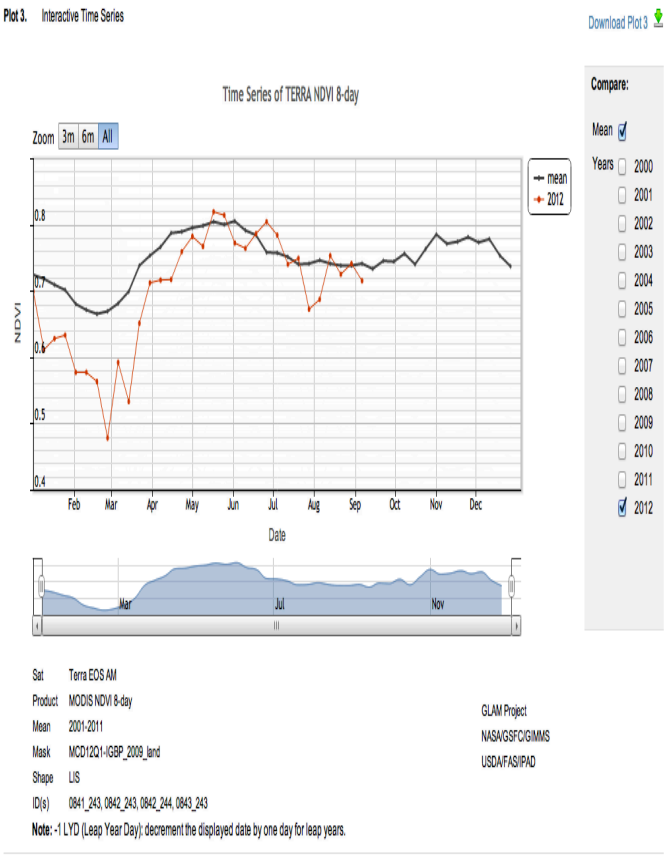
Extension for benchmark measures











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About NASA Predictive Surveillance Web RS component

Credits and acknowledgments

Special thanks and acknowledgments go to Clara Witt, Claudia Castaneda, Assaf Anyamba, Ken Linthicum, Emad Mohareb and John Haynes for generously sharing their time, expertise, imagery, and data

THANK YOU!

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